E-snakes and ladders: a hypermedia educational environment for portable devices

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Abstract: This article presents e-snakes and ladders (e-S&L), a game-based educational environment for portable devices. The e-S&L is based on the classic table game ‘snakes and ladders’ and enriches the table game with various types of activities, such as questions and answers and webquests. It provides a pleasant electronic-learning environment with an easy to use authoring tool for the instructor. The e-S&L is based on communication services and protocols (e.g. e-mail, short message service (SMS), MMS, HTTP and FTP) and on context-aware technologies. It supports learning standards, such as the IMS question and test interoperability (QTI) specification, the IMS Learner Information Package (IMS LIP) specification, e-portfolio, Dublin Core metadata creation and webquest. Furthermore, the article presents a learning scenario which is authored for demonstrating the e-S&L functionality. The findings from this study offer interesting insights into the extent to which computer gaming might be employed as a tool for supporting learning.

Keywords: authoring system; game-based education; handheld device; learning standards; m-learning; mobile-learning.

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1 Introduction

The growth of games on the internet is evidently increasing and there appears to be a close association between play and learning. Computer games enhance learning through visualisation, experimentation and creativity of play, and often include problems that develop critical thinking. Many different types of games have been developed, such as adventure, simulation, role-playing and strategy games. However, educational researchers have concentrated on two types: simulation and adventure (Quinn, 2001). Computer games in education have the ability to bring new and important skills into the learning environment. However, the convergence of computer games and learning is a relatively new phenomenon. Much more needs to be understood about computer games and the child audience, before education is recognised as a valuable role of computer games in the same way entertainment has already established it. Most learning in the future will occur through a technologically mediated learning/enjoyment combination of experiences (Bergen, 2000). The value of game-based education is recognised worldwide and can be ascribed to the generation of enhanced involvement of players in the learning process. Active participation is achieved when the player is enjoying himself while learning. Games effectively generate motive for active participation. Academic research reinforces the logical hypothesis that the learner, with active participation in the learning process, understands and assimilates more information. Given that learner’s interest is stimulated, a mass of elements accelerates their learning ability. These elements are:

1. questions

2. inaccuracies and multiple concepts
According to Prensky (2001), there are six structural elements that characterise games:

- rules that organise the game
- goals and objectives, the players strive to achieve
- outcome and feedback, which measure the progress against the goals
- conflict, competition, challenge and opposition leading to players’ excitement
- interaction, the social aspect in the game
- the representation or story exaggerating interesting aspects of reality.

These six elements need to be carefully designed and combined to create a fun and engaging game. From another perspective, mobile learning (m-learning) refers to the use of mobile devices as learning tools (Quinn, 2001). M-learning covers three different aspects:

- learning with portable technologies, where the focus is on the technology
- learning across contexts, where the focus is on the mobility of the learner, interacting with portable or fixed technology
- learning in a mobile society, with a focus on how society and its institutions can accommodate and support the learning of an increasingly mobile population.

M-learning is facilitated by a convergence of internet, wireless networks, wireless handheld devices and electronic-learning (e-learning). With a wireless handheld devices, the relationship between the device and its owner becomes one-to-one, always on, always there, location aware and personalised (Homan and Wood, 2003). The use of mobile devices offers many new opportunities for innovation, while the benefits of m-learning are:

- Connectivity. Access to information is available on a global scale.
- Flexibility. Learning can take place anytime and anywhere. The use of mobile devices in teaching and learning gives freedom for the learner to choose the time and shape where learning takes place. The possibility to choose the situation and context is the greatest added-value that mobile devices may bring to e-learning.
- Interactivity. Assessment of learning can be immediate and autonomous.
- Collaboration. Use of discussion tools can support collaborative learning beyond the classroom.
- Extended opportunities. Electronic content can reinforce and extend classroom-based learning.
- Motivation. Multimedia resources can make learning fun.
M-learning can be supported by most of the personal technologies, which vary from personal digital assistants (PDAs) to tablet personal computers (PCs) and from mobile phones to handheld audio and multimedia guides in museums and galleries. The key features of using wireless handheld devices for e-learning are its personalisation capability and extended reach. Wireless handheld devices have the potential to change the way learners behave and interact with each other. Certainly, mobile computers can assist learners’ motivation, may encourage a sense of responsibility, may help organisational skills, may help both independent and collaborative learning, may act as reference tools and may help track learners’ progress and assessment (Savill-Smith and Kent, 2003).

Mobile technology opens up the potential for children’s group collaboration (Danesh et al., 2001). Collaborative learning using mobile technologies comprises socio-technical, economic and historic facets, and a successful mobile application depends on the context of design. Activity theory can help mobile technologies designers to better understand the social and material relations that affect complex human learning and learners’ interaction with others as mediated by tools (Uden, 2007). Currently, mobile educational gaming and location-based and contextual learning are the main m-learning research areas. Learners may use mobile devices in the classroom to enhance group collaboration among learners and instructors using a pocket PC. Finally, learning outdoors is feasible (e.g. on field trips).

This article presents the e-snakes and ladders (e-S&L), a mobile educational gaming platform based on the classic table game ‘snakes and ladders’. Players are participating by using mobile devices with location detection characteristics. Their movements are projected as virtual movements into the graphical user interface (GUI) of the e-S&L game. Players are asked to undertake learning activities that are controlled through adaptive mechanisms like ‘snakes’ or ‘ladders’. The game innovates in providing a fun and entertaining learning environment that utilises location detection, wireless and cellular communication, as well as multimedia and internet technologies. The e-S&L constitutes a learning management system (LMS) along with an open source system (OSS) authoring tool. The development of the learning game model for e-S&L is within a social-constructivist pedagogical framework. Social constructivist (Vygotsky, 1978) emphasises intrinsic learning through social interactions and interactions with tools, is learner-centred, accepts plurality of perspectives and is associated with life-long learning processes (Kolb, 1984). In this article, we address the research question: Is it possible to create an advanced learning environment where learning, enjoyment and experiences can be combined in a universally applicable, dynamically authored and easy to apply and use m-learning game? The challenge is to create an effective game-based educational environment that allows the learner to maximise the use of mobile devices with context-aware technologies and to use them to achieve learning outcomes.

The remainder of the article is organised as follows. Section 2 reviews the related literature and Section 3 introduces the e-S&L game system. Section 4 presents a learning scenario authored for the e-S&L game. Finally, Section 5 closes the article with some conclusions and an outlook to further research.
2 Literature review

There are several m-learning projects in schools, workplaces, museums, cities and rural areas around the world. The m-learning project has tackled three pressing social/educational problems that relate to many young Europeans:

1 poor literacy and numeracy
2 non-participation in conventional education
3 possible social exclusion.

The MOBIlearn project explored context-sensitive approaches to informal, problem-based and workplace learning by using key advances in mobile technologies. In the MOBIlearn project, an m-learning architecture was developed to support creation, brokerage, delivery and tracking of learning and information contents.

Farooq et al. (2002) have extended an existing PC-based online learning community (called MOOsburg) to wireless handheld devices to allow students to participate in community education programmes on environment and ecology to discuss their findings from remote field trips. As students collect and analyse environmental data, they can either chat with their peers or interact with a database on the server. Another project (Lehner and Nosekabel, 2002) extended an internet-based virtual university to mobile devices by developing an m-learning platform called wireless e-learning and communication environment. This complements the e-learning environment by translating some of the contents for wireless handheld devices and supplements it with new information, such as event alerts, phonebook, calendar and other campus services. Both systems combine the browser-based pull technology with the WAP-based push technology to enrich the student’s learning experience and support the conversational theory of learning.

Two other studies at European universities have focused exclusively on use of SMS technology as collaboration tools for m-learning. The first study (Bollen, Eimler and Hoppe, 2004) emulated a wireless handheld device on a PC to allow students send SMS messages on various discussion topics which were aggregated and categorised by the instructor, using an electronic whiteboard in the classroom. Criteria, such as sender, receiver, time and others can do the categorisation. The second study (Stone, Briggs and Smith, 2002) evaluated the effectiveness of the SMS campaign as a conversational mechanism in context of developing better quality mobile teaching and learning environment. Both studies demonstrated that students like using SMS and they were responsive to the use of W/H devices for interaction and learning.

Another sophisticated m-learning project is the Mobile Author project (Virvou and Alepis, 2005) which allows instructors to create an intelligent tutoring system (ITS) in any subject domain for their students. This system can be accessed either from a PC or wireless handheld devices. The ITS can assess, record and report student performance to the instructors. Motiwalla (2007) demonstrated how learning can be extended to wireless handheld devices with an m-learning framework and developed a prototype application for this framework. The application was evaluated with students from both online and on campus classroom environments to explore m-learning feasibility and get valuable feedback from the potential users. Yuhsun and Mills (2007) present an innovative model for m-learning and examine the challenges of using mobile technology in education. Their work describes a model to facilitate m-learning design and to achieve better
m-learning outcomes. Parsons, Ryu and Cranshaw (2007) propose a conceptual framework for m-learning applications that provides systematic support for m-learning experience design. Their framework is based on a combination of a game metaphor and several studies of m-learning contexts.

Until now, there are small number of mobile systems that integrate playing and learning, such as the Cooties Game or Geney (Danesh et al., 2001), or Savannah (Facer et al., 2004). They focus on role-play or simulation. Prototypes and commercial products of location-based games in real life environment, such as CYSMN (Benford et al., 2003), Pirates (Björk et al., 2001), Mogi (Hall, 2001) or MobileGame (Schwabe and Goth, 2005) show that people like to play with the new options, but these games focus purely on entertainment. Interactive mobile games have been implemented to support the development of decision-making skills, albeit in a simulated situation science students were asked to solve a core problem (Sánchez, Salinas and Sáenz, 2006). The mobile game-based learning (mGBL) project (http://www.mg-bl.com/) designed new learning game models for the young adult market. In the mGBL framework, three novel game models were developed. Game 1 is a hybrid of a Quiz and Simulation, Game 2 is a board game with ‘2D’. The development of these two models has been reported in Mitchell et al. (2007). Game 3 is ‘Get real’, a multi-player game that uses the web-enabled mobile camera phone to support both cooperative and collaborative learning, and recognition-primed and creative decision-making (Mitchell, 2007). Wu et al. (2004) presented the game ‘Real Tournament’ which gathers real-time contextual information, e.g. physical location and orientation from the players and injects them into the game engine to generate game events.

Nova et al. (2007) present an experimental research that focuses on collaboration in a multi-player game. They study the cognitive impacts of awareness tools, i.e. artefacts that allow users of a collaborative system to be aware of what is going on in the joint virtual environment. The authors found that using awareness tools have a significant effect by improving task performance. ‘Hubbub’ (Isaacs, Walendowski and Ranganathan, 2002) is a mobile instant messenger (available on PDAs). It allows people to stay connected as they move. It provides awareness information among distributed groups by giving cues about presence, authorship, identity and activity. Each time a partner becomes active after being idle or offline, a sound plays indicating that someone became active, followed by that partner’s Sound ID, so that people can tell who became active without looking. There is also an ‘activity meter’, indicating each partner’s level of activity within the last 15 sec. Hubbub enables users to meet in opportunistic interactions and then to work over the distance.

The main disadvantage of the most referred prototypes is that they are not OSS for authoring learning scenarios for mobile gaming. Moreover, from the authoring point of view, the most mobile games do not adopt e-learning standards. M-learning games have the potential to offer players agency rather than the trickery and perception of control they have in their interactions (Thomas, Schott and Kambouri, 2002). Situated learning experiences that give players the opportunity not only to write the content of their own stories, but also to create structurally the games they play are only a mobile device away. Towards this direction, we have worked in the e-S&L project.
3 The e-snakes and ladders project

The e-S&L combines the classic table game ‘snakes and ladders’ with e-learning practices. It constitutes a game-based LMS that utilises a variety of activities, like student-assignments or multiple-choice questions combined with an authoring tool. The e-S&L is based on the ‘snakes and ladders’ game as the underlying motif and encapsulates all the attractive characteristics of this game in an e-learning environment. Moreover, the e-S&L game system enriches the learning procedure with elements, such as game, fun, entertainment and the use of multimedia in order to become a fun, pleasant and entertaining learning process for the player. The player is called not only to discover, but also to test his knowledge by a variety of activities that are delivered through a familiar, unconventional and fun environment.

The e-S&L combines learning standards and wireless network technology along with location aware technologies, and thus, it provides an environment with unlimited application possibilities. It provides the technical specifications to virtually simulate and project the physical movement of the involved players (learners) into the virtual game environment as movements of avatars. For example, the environment of a museum can be electronically simulated and projected under the divided cells of the game workplace, while the physical movements of the players can be monitored and projected into the game workplace through the use of location aware technologies. The activities the player is induced to undertake may vary from simple questionnaires to objects or elements that the players can view in their physical space and collect evidence, based on some educational scenario supporting basic principals of situated learning.

The e-S&L game is described in terms of Prensky’s six structural elements. The scenario describes the global rules. The players have the goal to solve the tasks (and ultimately learn). The real-time technique gives you direct feedback on the current status in the game and on the outcome achieved so far. Conflicts and competition are realised through the opportunity to gain points (e.g. by solving tasks). By playing in groups, there is interaction in the game. This effect is additionally supported by the chat function. The representation is realised through the orientation on the digital map and the augmentation of the reality with digital objects. These structural elements characterise the e-S&L game and engage the player.

3.1 Rules of the game

The GUI of the e-S&L exploits the use of objects that are especially designed to support the activities and the rules of the game. These objects are the following.

- **Ladders.** The base of the ladders is the vaulting horse for fast advancing through the environment of the game. Ladders use trigger activities in the same way questions are used in instructional management system (IMS) simple sequencing (Warwick, 2005). The players/learners successfully attempting an activity associated with the cell on the base of the ladder automatically prove themselves worthy to climb at the top of the ladder and consequently at the top of the game (Figure 1).
• *Snakes.* The cell containing the head of a snake is a control point activity for the knowledge level of the student. The use of the snakeheads is similar to the control used with trigger questions in IMS Simple Sequencing. If the player fails on the trigger-activity, s(he) is returned to a cell on a lower level at the end of the snake’s tail.

• *Dice.* The electronic dice plays a key role in controlling the adaptation rules of the game. The virtual ‘throwing’ of the dice controls the movement of the learner. If the scenario predicts a rule on a specific cell (i.e. if the learner must go two cells ahead in case he fails on an activity corresponding on his current cell), the dice can be fixed for this particular player to forward him two cells ahead. The dice serves as a control mechanism that applies the adaptation rules set by the instructor.

The environment of e-S&L is based on the use of cells. Learners use the virtual dice and advance through the environment by taking on the activities corresponding to the cell they are positioned. If players successfully fulfil the activity’s challenges, they are allowed to keep their position, and if they do not, they are returned to their previous position. Each cell has an activity attached that is either static or that is pooled out of an activity tank randomly or dynamically, based on rules and/or specific user characteristics.

The activities are structured hierarchically in accordance to their difficulty degree and to the educational scenario. As the players advance through the e-S&L environment, they are ‘climbing’ advanced difficulty levels of the game (Scaffolding). The goal of the players is to be the first who will reach the top-exodus having shown the ability to successfully complete the activities of the last and most difficulty level of the environment.

*Figure 1*  Higher level on higher row implies advanced difficulty degree and vice-versa
3.2 **Supported learning standards**

The supported learning standards combined with the supported platforms are the following ones.

- **QTI.** An instructor can create questions stored in the IMS QTI specification. This specification for tests and items allows these to be authored and delivered on multiple systems interchangeably. IMS QTI is designed to facilitate interoperability between systems.

- **Webquest.** It is a learning activity used by educators inside eS&L as an inquiry-oriented activity in which some or all the information that learners interact with, comes from resources on the internet.

- **IMS LIP.** The e-S&L stores a user profile for each learner based on IMS learner information package (LIP) protocol which includes demographic data, learning style and performance on activities. The structure based on these protocols was achieved to cover all the needs that the keeping of a user profile serves. IMS LIP is combined with the personal portfolio (IMS, 2001).

- **E-portfolio.** It stores digital content, hypermedia content and other kind of similar content that are collected through the participation of the learners in all the implemented activities of e-S&L. The structure of this content, recorded in e-S&L, is based on the e-portfolio protocol. This allows the combination of a learner’s portfolio with his user profile and offers also the ability to allow exchange of digital content between learners with similar interests or historic background.

- **Dublin core metadata.** The use of metadata is also implemented inside e-S&L (15 under Dublin core) in order to achieve best filing, categorisation and index allocation of the environments content.

3.3 **Roles and modes of operation**

The proposed system supports two roles:

- The players (learners) who participate in the game by using the virtual dice and taking on activities as they move from cell to cell based on the dices results and the results on the activities they participate.

- The authors (learning instructors). The author learning scenarios using the authoring tool or other tools that follow the same learning standards. An author also monitors a learners’ performance.

The e-S&L system provides two different interaction operating modes. The first operation mode is the application and the interaction environment of the player where the actual game is played. The second mode comprises the authoring tool that serves as the control panel and the design environment of the instructor.

3.3.1 **Potential presentations of e-snakes and ladders graphical user interface**

When the player participates into the game, the environment is adapted to his/her device (Figure 2). The displayed content and the form of the content are adjusted in order to ‘respect’ the limitations of the display unit and the technology used. So, if the player uses a PDA or a pocket PC with limitations in the display resolution (i.e. 320 × 240), the
GUI-environment, s/he sees only a segment of the one depicted on a PC. This is the result of a smart content transformation that is achieved by using script language in order to select the appropriate XSL transformation file (based on the header input), which forms the XML content in a display resolution adjusted manner. The final result is always the same. Players view the content either in hierarchical served segments or all at once depending on the device they use. The players participate into the game by clicking the dice. If players successfully pass the activity encountered, they stay at the specific cell or else they are returned into their previous position.

3.3.2 The authoring mode

For example, the instructor prepares a learning scenario that will control the understanding of the wave nature of sound by 12 year old pupils at the last class of an elementary school. The instructor is entering the activities inside the environment (see Figure 3) with the help of the authoring tool and adjusts the settings for each activity (question, webquest or other) based on the difficulty grade of it. Each activity is allocated inside the environment based on the prerequisite knowledge level. The setting of the cells – activities is hierarchical, meaning that each higher row has cells with allocated activities of higher difficulty. As a result, as the player advances through the cells and tries to conquer the top, which is the ultimate destination, he encounters more difficult activities with each row he overcomes (scaffolding). The instructor can also use another tool that is compatible with the learning standards used inside e-S&L. So, if the instructor chooses to enter an activity that is a questionnaire, he is allowed to use a known open source tool like ‘hot-potatoes’ that structures queries under QTI protocol. Or if he chooses to enter a specific activity with expected results and evidences, he can use the webquest authoring tool. Through the authoring environment, the instructor decides which objects are going to be used in this specific learning scenario. The instructor allocates the objects (snakes and ladders) with specific cells inside the environment. Then, he chooses which cells are going to ‘bear’ the bases or the tops of the ladders and which cells are going to ‘bear’ the heads or the tails of the snakes (Figure 3).

Figure 2   Playing the game: the graphical user interface for desktop platform
**Figure 3** The instructor enters a question and allocates it to a cell with a level difficulty level gradation.

**CONTROL PANEL**

<table>
<thead>
<tr>
<th>Activity data</th>
<th>Question data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Type: Questionnaire</td>
<td>Through which material the sound has the lower dissemination speed?</td>
</tr>
<tr>
<td>Category Level: Level 1</td>
<td></td>
</tr>
<tr>
<td>Type: Simple Cell</td>
<td></td>
</tr>
<tr>
<td>Connected to activity: No</td>
<td></td>
</tr>
<tr>
<td>Connected to cell: 23</td>
<td></td>
</tr>
<tr>
<td>Random access: No</td>
<td></td>
</tr>
<tr>
<td>Timing: No</td>
<td></td>
</tr>
<tr>
<td>Type of question: Multiple choice</td>
<td></td>
</tr>
<tr>
<td>Number of answers: 4</td>
<td></td>
</tr>
</tbody>
</table>

For example, the instructor may choose cell 29 to allocate (as depicted in Figure 4) a question with difficulty degree B’ and place the base of a ladder there. If the player enters cell 29 and answers successfully, s(he) will immediately advance to cell 53 (the top of the ladder). Reversely, the instructor may allocate cell 51 with a question of difficulty degree C’ and place the head of a snake there. If a player enters cell 51 and answers unsuccessfully, s(he) ends up at cell 8 at the tail of the snake.

The instructor can also allocate other kind of activities like a webquest. These activities may vary from a simple browse through the web in order to find specific information or sending a picture taken based on a mission and send it back to the
instructor using MMS. Or even conduct experiments, record and e-mail them in order for the instructor to collect online. The instructor can also use available webquests based on the known protocol that he can download from the web in order to minimise his effort. He can even upload his creations in order to share them with other instructors.

3.4 Information system architecture

The e-S&L is based on a three-tier client–server architecture which is comprised of three functional entities:

1. data tier
2. business tier
3. presentation tier (depicted in Figure 5).

The game server uses the information received from the (mobile) clients to determine what happens in the game and thus, what the players have as an experience. For example, the server interprets incoming location information from the clients with respect to maps that relate the virtual dice to the physical game space. In particular, the game server serves the requests of the clients (thin or thick) with the use of a script language by reading the data of XML files. The information is transformed with the use of XSLT files depending on the platform (device) used by the client. Using this way, the information is divided into segments allowing the projection of only the absolute necessary information, when the device of the client does not allow it due to display or technology limitations (PDA’s and smart phones). During the game play, the application monitors and logs the movements, actions and consequences of the players as reported to the server.

The e-S&L environment has been designed for intranet and internet use. Furthermore, it supports the use of wireless local area network (W-LAN) and the use of hotspots combined with location aware features. Figure 6 depicts the topology of e-S&L. The idea behind the wireless innovation is the liberation of users from the immobility that PC’s impose and the allowance of internet services on mobile devices, such as PDA’s and smart phones. By this way, the author of a learning scenario is allowed to assign activities that might involve movements on physical terrain (and not only virtual) and collaboration assignments with physical contact.

Figure 5  The three-tier architecture of the e-snakes and ladders supporting mobile platforms

<table>
<thead>
<tr>
<th>Data Tier: Data recording in the form of XML files</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Tier: The logic of the application running on the Server</td>
</tr>
<tr>
<td>Presentation Tier: The Graphical User Interface (GUI) running in thin clients (e.g. PDA) and in other clients (PC, laptops)</td>
</tr>
</tbody>
</table>
4 Authoring a learning scenario

In this section, we present a learning scenario to demonstrate the authoring capabilities provided by the e-S&L system. In a location aware environment, the physical movement of the players can be allocated with the virtual move of the avatars inside the game. The same could be applied indoors with the use of wireless fidelity (Wi-Fi) or worldwide interoperability for microwave access (Wi-Max) combined with location detection techniques. The goal of the described scenario is to allocate the physical environment of an archaeological location with the virtual environment of e-S&L. The physical movement of the players corresponds to the virtual movement of the avatars. Every movement inside the location in question can be allocated with movements of the avatars inside the virtual environment. The movement of the avatars through each cell can be allocated with the physical movement of the players through specific geographic squares that can be rooms or locations of the physical environment. Each allocation occurs based on the geographical coordinates which are provided by the location aware technology used. If the physical movements involve indoor activity, the use of hotspots or alternative location detection tools like Navizon is the appropriate. If the movements occur outdoors, the use of global positioning system (GPS) is the right one. The first scenario involves outdoor activities; so the use of GPS is chosen in order to pinpoint the location. The second scenario involves indoor activities; so the use of hotspots is suggested. The location aware scenario could also be applied for indoors activities, like using a museum instead of an archaeological location. The only difference would be the ‘black box’ which would be a chain of hotspots triangeling the signal and outputting the $x$ and $y$ into the environment. The scenario could also work with the use of free location detection technology. Technology combining GPS, cellular, Wi-Fi that are free to use, for example Navizon$^4$ (Figure 7).
Because this technology is based on the contribution of users and it is community oriented meaning, users are putting the feedback regarding info of each location, it is not so widespread in every country. This is the reason it was not implemented in this scenario, as it has minimum info regarding our example location.

4.1 Discovering the Acropolis of Athens

The scenario involves a visit at an archaeological location. The students are divided into four groups of five participants. Every group has a hand held device (wireless handheld devices) available which is equipped with GPS, Wi-Fi, GPRS, cellular and many other technological innovations (i.e. HP6915).

Step 1. The instructor (teacher) designs the learning scenario and adapts every parameter of it with the use of the authoring tool into the environment. The instructor has to follow specific steps while implementing the scenario in order to allocate the physical world into the virtual environment. This scenario sets as a goal to allow the students to advance from a specific spot of the archaeological location into another after fulfilling a specific activity the instructor has affiliated with the location.

Step 2. The instructor uses the authoring tool to divide the location into geographic cells in order to allocate them with the cells of the environment (Figure 8). S(he) just enters the coordinates of the four angles into the environment and the cells are automatically
correspondent to the geographic cells of the location. For this, s(he) uses a GPS enabled device or s(he) can choose to find the coordinates of each angle by using the addresses of the surrounding streets (i.e. http://www.gpsvisualizer.com/geocoding.html).

**Step 3.** The environment acknowledges the geographic squares as cells of the game and allocates the movement of the students inside the archaeological location as movements of avatars inside the game. The input for this allocation is achieved by using the GPS receiver of the pocket PC as a black box that is ascribing coordination variables (Example = 39 54 32 W). These variables are fed into the environment and are transformed into $x$ and $y$ coordinates inside the virtual game.

**Step 4.** The groups are prompted to fulfil activities like answering a questionnaire regarding a statue in front of them or taking pictures (using the pocket PC) and sending them to the teacher with MMS. These multimedia files are recorded into a common folder and will serve as a shared data repository. They are also admonished to exchange info and data with other groups and to communicate any questions they might have between them, encouraging collaboration and information exchange between groups. Each activity is automatically generated in the display of their pocket PC based on their position inside the controlled environment. The location detection technology allows every group to see where the other groups are and to decide if they want to collaborate.

**Step 5.** The instructor allocates an activity to each cell of the virtual environment and places the objects to each cell he has designed to be the receptor of a ladder or a snake (Figure 8). More specific the instructor places a Question, in this example in cell 1 (tile 24) which is also the entry cell of the game. The question is the following:

Odeon Herodes Atticus was build in:

1. 160 and 174 BC
2. 60 and 74 BC
3. 60 and 74 AC
4. 160 and 174 AC.

If the players ‘throw’ one (1) with the virtual dice, they advance into the first cell of the virtual environment which is geographically allocated in the entry point of Odeon Herodes Atticus. The moment they physically advance into the entry point of the Odeon, they are recognised by the GPS location aware mechanism of the software and their physical movement is screened into the virtual environment of the game. When they have reached their target, the system ‘delivers’ the question, the instructor had prescribed while preparing the scenario. What they see, in case they use a Laptop or a PDA, is shown in Figure 9.
If the players choose the correct answer, which is (a), they advance into cell 11 because cell 1 hosts a ladder base and has a prescribed escalade up to cell 11 recorded by the instructor. This is the adaptation mechanism that is implemented into the game in order to advance the player that has (or seems to have) above average knowledge of the Acropolis history directly into Acropolis. The ladder mechanism is a virtual representation of the IMS simple sequencing adaptation rule. In any other case, the players are asked to return to cell 0 which is ground zero of the game. They will have the opportunity to try again after all participants have ‘thrown’ the virtual dice ones.
Step 6. The winner is the group that first exits the location (cell 20 – the sanctuary of Jupiter) having successfully fulfilled all the activities.

At the final stage of this scenario, the following points should have been achieved:

- After this game-introductory course, all the participants should be familiar with the Acropolis of Athens, know historic details about structures and statues. They should have collected and recorded these details along with multimedia data such as photos or videos. All the collected data will be available in a common folder for each participant to access.
- The group work should boost collaboration and synergy among group members. They should discover that working for a common goal as a team produces maximum results.

This scenario is simple and easy to apply. It requires good knowledge of the Archaeological location in order to utilise the maximum of the games potential. It is also simple to apply from a technical perspective as it bases the location aware mechanism on GPS because the scenario mainly prescribes outdoor activities.

4.2 Findings and learning outcomes

In order to record and evaluate the e-S&L performance, a research analysis was conducted. This analysis consisted of data collection and analysis based on Stanford University’s ejust (Research methodology: http://ejust.stanford.edu/index.html). A three-step research methodology was completed with the use of:

- personal interviews
- surveys and questionnaires (three-phase: 1st, 2nd and follow up)
- log data mining.

The aim of the personal interviews was to understand how the students feel about e-S&L. The personal interviews were contacted separately with each user. The general findings of personal interviews were quite encouraging:

- most of the players suggested that several courses should be adapted to this tool
- almost all of the players stated that if all of the courses were that interesting and entertaining, they would seek forward to go to school everyday
- some of them even had some imaginative ideas of how to implement exchangeable bonus tactics they were used by playing interactive games
- some complaints were made in regard to the small screen resolution (240 × 320) and the amount of content that had to be presented, forcing them to use the scrollbar continuously in order to interact.

Surveys were conducted in a three-phase manner. The first phase was conducted right after the experiment; the second phase was conducted the day after the first phase, and the third one after the same lesson was taught in a traditional classroom. All of the three-phase surveys scored an average of more than 70% positive results. Details are shown below:
Questionnaire about e-S&L; sample: \(n=20\) 11 males - 9 females -- ages: 18-20; IT familiarity: Good 6 (30%), middle 7 (40%), low 7 (40%).

**Figure 10** Survey results and graphics

<table>
<thead>
<tr>
<th>Statement</th>
<th>I agree</th>
<th>Undecided</th>
<th>I disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would recommend this Game to my friends</td>
<td>17</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>This question was designed in order to measure the acceptance rate of the e-S&amp;L and returned one of the two most positive results.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning with e-S&amp;L was easy</td>
<td>15</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>This question was designed in order to measure the easiness of e-S&amp;L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy using the e-S&amp;L</td>
<td>16</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>This question was designed in order to measure the acceptance of the innovative way of learning in contrast with the traditional way the players were used to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think this Game is inconsistent.</td>
<td>5</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>This question was designed in order to measure any negative impact created by inconsistency of e-S&amp;L as it combines virtual and physical world in one common environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can understand and act on the information provided by this Game</td>
<td>16</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>This question was designed in order to measure the apprehension of players using e-S&amp;L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is too much to read before I can use the e-S&amp;L</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>This question was designed in order to measure the manageability and simplicity of e-S&amp;L and to confirm that not to much instructions overload has been a burden for players</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The e-S&amp;L has a very attractive presentation</td>
<td>14</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>This question was designed in order to measure the acceptance of e-S&amp;L’s GUI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is easy to forget how to do things with this e-S&amp;L</td>
<td>2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>This question was designed in order to measure the familiarization of players with e-S&amp;L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The e-S&amp;L has changed the way I used to view learning before</td>
<td>16</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>This question was designed in order to measure the innovation impact on traditionally educated players</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would use the e-S&amp;L daily</td>
<td>17</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>This question was designed in order to measure the acceptance rate if e-S&amp;L was to be used more widely</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Pie charts](image)
The log data mining procedure has been processing the time between dice throws and the time it takes for players to use the same feature for the second and third time. The analysis has been focused on acknowledging the familiarisation gap of new players with the environment. Log recordings have shown that familiarisation with the environment and the features used is rising exponential from ‘dice-throw’ to ‘dice-throw’. Players are familiarising themselves quick and efficient in order to participate in the designed procedures.

Instructor findings were based on personal interviews of two guest instructors participating as observers at this trial. They found the authoring environment simple and handy but were having second thoughts regarding their technological adequacy to conduct such a trial on their own in terms of location detection technology, without proper technical support.

Based on the above three-phase evaluation, the main advantages of the eS&L learning game are:

- it shows flexible and creative approaches to problem solving, and it enhances players’ creativity
- it manages information effectively in a range of media
- it acts in an ethical manner
- it generates output which is literate, numerate and coherent
- it encodes its data in e-learning standards in order to promote interoperability and shareability
- it provides players with intellectual stimulation
- it fosters interaction and teamwork among learners
- it allows players contributing to the learning experience.

The presence of mentors or colleagues who can discuss the above learning outcomes will probably increase the use of eS&L game.

5 Conclusions and further work

In this article we introduced the e-S&L, a mobile educational gaming platform that is based on the classic table game ‘snakes and ladders’. This platform incorporates an advanced authoring tool that complies with the most learning standards (e.g. IMS QTI, IMS LIP, webquest). The key-idea of the e-S&L game is the use and combination of location detection techniques, m-learning and learning standards. E-S&L combines the potential of mobile and games technology in a novel and innovative way to support children’s learning. An instructor can author structural and open source learning scenarios using the e-S&L authoring tool as it uses learning standards. There is the possibility of embedding adaptation rules that follow known protocols like IMS Simple Sequencing. These rules are applied with the use of the virtual dice which serves as a control mechanism. For demonstrating reasons, we presented the authoring of a learning scenario. The e-S&L prototype offers many attractive insights into the extent to which mobile gaming could be used as a tool for sustaining learning, and a number of major
challenges that this format raises for the organisation of learning with schools and the
design of such resources. More detailed research is required on how particular learning
scenarios and players require different gaming material (e.g. questions) for distinct
learning outcomes (e.g. learning performance). For example, we aim to redesign the
questionnaire (Figure 10) to quantitatively measure learning outcomes. A major
bottleneck from the pupil’s point of view for our current application was the user
interface. Therefore in the near future, we plan to explore how to enhance user interfaces
with speech recognition technology. For example, interactive voice recognition
technology can be used for voice-activated user navigation and voice messages can be
converted to text before sending them on the discussion board. These enhancements are
crucial for sustaining the growth of mobile devices in education.

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Notes

1 The m-learning project: http://www.m-learning.org/.

2 The MOBIlearn project: http://www.mobilearn.org/.


4 Navizon: a position system that combines GPS, Wi-Fi and phone positioning http://www.navizon.com.